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It has been said that the control of the oceans is the control of the trading world. This has been true from ancient times, with the far-reaching Phoenicians, Egyptians and Qin Chinese trading with primitive sailing vessels, to the mixed oar-and-sail driven water-borne merchants of 0 CE – 1000 CE, through the dawn of the age of square and triangular sails of the latter half of the second millennium CE; now in modern times ocean-going vessels with steam or gas-turbine powered vessels haul more tonnage than entire fleets of past eras, and their military counterparts bear enough firepower to level small countries or irradiate whole continents. Various ships and fleets in many eras have gained acclaim for their crews' skill, builders' capabilities and commanders' prowess; the Athenians in the Battle of Salamis, Sir Francis Drake and the *Golden Hind*, Admiral Nimitz and the Battle of Midway, for example. Sadly, one of the most overlooked of these is Zheng He, a fleet commander in the Ming Dynasty from 1405-1433, who nearly had the ocean-going world under his bow. His fleet's seven voyages relied upon vessels which had levels of technology and skill of both builder and crew not seen in the west until the age of colonialism was fully underway. It is thus appropriate to contrast such vessels to contemporary and later western designs of one or two centuries afterwards in terms of hull composition, design, and capacity.

Little can be said about taking evidences and examples in a bubble; thus, one needs to look at Zheng He's background before his voyages first to understand the reasons for leading the expeditions, determining his ports of call, and why they were of importance. The most trusted servant of the Ming emperor Yongle (also known as Zhu Di), Zheng He was a Muslim by upbringing from and this hints at possible reasons for either his or the emperor's intentions to bring China westward by sea. It was possible their knowledge of trade routes west of China that flowed through the Middle East but did not directly connect to China would be of significant value to the empire, and thus could be incorporated into the tributary system.

The use of naval ventures was opposed by the Confucian officials of Zhu Di's court, as they viewed these attempts to "enroll far-flung states into the tributary system…" as being "not cost-efficient"[1]. The justification for the inefficiency of the tributary system was that it worked best with "far-flung or remote states"[2], which would appear to satisfy the very reason of the tributary system. The other explanation is the hostility of Confucian officials to the power of court eunuchs; in paraphrasing author Louise Levathes, Edward Dreyer notes,

> "Confucian officials opposed the voyages from the beginning of Zhu Di's reign, so the entire project was run by eunuchs and was essentially the whim of a strong-minded emperor." [3]

In this light, the bureaucratic distaste of overseas ventures is apparent, and only the direct orders of the Yongle emperor created the far-flung cruises. The eventual termination after the deaths of Zheng He and the transition to another emperor were set before the Zheng He's fleet even set sail. What was done during those times was something that would surpass all contemporary naval powers.

There are several facets to a successful ocean-going ship's design, with the most important being the function. Form, crew complement, armament – these all serve the function of the vessel. The key vessels of the voyages, Zheng He's 'Treasure Junks' or *Bao Chuan*[4], had the purpose of displaying the might and awe of China to encourage other nations to enter the tribute system[5]. This somewhat ambiguous function means that the ships had to be able to transport Chinese goods, troops, and livestock[6]. This gave rise to a need for relatively large vessels, with figures ranging from 400 ft[7] to 440 ft[8] in length by 160 to 180 ft beam[9]; this necessitated drydock construction facilities of up to 210 ft wide per dock[10], and the length of any of the seven drydocks was 1,500 ft[11]. These facilities at Longjiang required 20-30,000 men to construct the Treasure Fleet of the Yongle emperor[12].

One can imagine the technical difficulties in building a vessel of such a size; the dimensions are analogous to four modern American-made Oliver Hazard Perry-class Frigates laid port-to-starboard[13]. The design can be compared to three contemporary vessel classes of European origin of the same and following century: the galley (the *Grace Dieu*), the carrack (the *Santa Maria*), the caravel (the *Niňa* and *Pinta),* and finally the galleon (the *Golden Hind*).

The general construction of the Treasure Junks began with the laying of the hull and bulkhead placement at regular intervals.[14] These were made out of elm, camphor, sophora and cedar; the rudder was also made of elm[15]. The keel of the ships was bound by iron hoops[16], presumably to reinforce the structure of the wooden spine. The displacement of the ships has varied greatly depending upon the scholars researching the issue, running from a mere 800 tons to 3,100 tons, 14,000 tons and 20,000 tons[17]

The masts, the most important part of the propulsion of the ships, were made out of fir and laid down in front of the bulkheads[18]. Each Treasure Junk had 9 masts, with a non-centerline layout of alternating port-and-starboard emplacements of the mast beams[19]. When it comes to ship rigging, square sails are vastly more efficient in terms of required manpower and speed with the wind to triangular sails, but triangular sails can be used for tighter maneuvering, and used to cut across the prevailing winds without coming to a dead halt[20]. It can only be theorized that a full ship-rigged vessel like the Treasure Junk, with minimal if any triangular, or 'lateen' sails, would be able to use the prevailing wind to full effect with the multiple masts catching the air currents. The off-center mast layout would allow the sails to pivot in a far larger area than western designs, thus the square-rigged sails could theoretically have been used when cutting across the wind to the same effect as a lateen sail. The sails themselves were made of red silk[21].

The less visible assets of the ships were just as necessary and vital to their success on the seas as the general layout and build. Waterproofing was done by using a tung oil mixture, which

1. Patricia Ebrey, *Cambridge Illustrated History of China* (Cambridge: Cambridge University Press, 2006), 209
2. Ibid, 209
3. Dreyer, 198
4. Louise Levathes, *When China Ruled the Seas: The Treasure Fleet of the Dragon Throne, 1405-1433* (New York: Oxford University Press, 1994): 80
5. Wu
6. Evan Hadingham, *Ancient Chinese Explorers* (2003; accessed 2 December 2007); available from http://www.pbs.org/wgbh/nova/sultan/explorers.html , 1
7. Wu
8. Ebrey, 209
9. Dreyer, 199
10. Ibid
11. Levathes, 77
12. Ibid, 76
13. "FFG-7 OLIVER HAZARD PERRY-class" *Military Analysis Network*, Federation of American Scientists (2000; accessed 2 December 2007); available from http://www.fas.org/man/dod-101/sys/ship/ffg-7.htm
14. Levathes, 77
15. Ibid
16. Ibid, 81
17. Dreyer, 199
18. Ibid, 76
19. Hadingham
20. Fredrik Sandström "The Square Rigging" *Sailing Ships* (accessed 2 December 2007); available from http://sailing-ships.oktett.net/square-rigging.html
21. Levathes, 82

had to "be mixed and cooked before it would harden into the excellent waterproofing material that had been in use on Chinese ships since the 7th century."[22] The bulkheads were sealed to the deck above them and the hull below, forming watertight bulwarks which greatly enhance the structural stability of the Treasure Junks[23]. This watertight, compartmentalized design did not become widespread in the west until long after the sail had been abandoned as the primary method of propulsion, with the advent of the civilian liner *Titanic* in 1911 – over 600 years after the first voyage had begun. Quite possibly most significant in terms of navigation and long-term survival, Chinese expertise in electro-magnetism yielded a compass during the Song dynasty around the turn of the century[24], which was put to use in guiding the fleet from Nanjing to its later ports of call.

The ships had an opulent style of decoration, as Levathes describes:

> "… the treasure ships were appointed for luxury. There were grand cabins for imperial envoys, and the windowed halls and antechambers were festooned with balconies and railings. The ship' holds were filled with expensive silks and porcelains for trade with foreign countries."[25]

The Treasure Junks were no slouch in armament, either. They were equipped with 24 cast-bronze cannons, each with a range of 800-900 ft.[26] While the ships were not primarily built for warfare – they had escort vessels, of the 165 ft. 5-masted *fuchuan*[27] design for that purpose- they still were capable of defending themselves if need arose.

So, how do these massive vessels lost to the annals of time compare to the most prominent vessels of their century, and the next? Each of the three European designs had its advantages relative to its era, and yet in many ways they were obsolescent thanks to the Chinese advances in the early 1400's.

The caravel, a lateen-rigged boat of far smaller proportions than the Bao Chuan, was used heavily by the Portuguese of the 15th and 16th centuries. George R Schwartz, a naval archeologist from Texas A&M, has assembled a history of the class of the ship, describing them as having, "a gently sloping bow and single stern castle…[with] a mainmast and a mizzen mast that were generally lateen-rigged."[28] It should be noted that, when prepared for travel on the open oceans, the lateen sails would be exchanged for square ship rigs, allowing it to keep pace with the carracks used for trade and conquest. The ships were capable of traversing shallower waters than their contemporary carracks or later galleons due to a shallow draft and smaller size, being only 60-100 ft. in length and about 23 ft. wide and displacing only about 50 tons.[29] This light displacement and narrow beam meant it could be used to explore up rivers and other shallow bodies of water. The *Niña* and *Pinta,* of Columbus's voyage, were of this class.

The next largest vessel of European comparison, the carrack, was the premier maritime ship of the medieval ages. Considered the first intentionally-designed ocean-going vessel by the European sphere of influence,[30] the three to four masted vessels were square-rigged on the foremast and mainmast, with the mizzen mast being lateen-rigged for maneuverability in crosswinds. The carrack sported a forecastle and aftcastle, not too different from the designs the Chinese junks of varying sizes had employed. This did, however, make the narrower carracks topheavy. The carrack had a variable design and displacement depending upon the builder, intention, etc. Some examples are given for Genoese carracks during the 15th century with a displacement of 1,500 tons and Portuguese carracks displacing 2,000 tons [31]. Little is mentioned about their armament except that the galleon forces their obsolescence in war by virtue of being its evolutionary descendant. After this point, it could be presumed that their armament followed a lighter pattern, if at all, to that of their larger galleon descendants. Columbus's *Santa Maria* was of this type, with a length of 85 ft.[32]

The galleon, the primary sailing vessel of the seafaring European nations in the 16th- to mid 18th century, replaced the carrack as the preferred liner for trade and war. Of the changes between the two designs, the widespread adoption of cannons in the form of the demi-culverin 9-pounder[33] and the flattening of the forecastle for stability and structural reasons made the construction of any new carracks solely for the purposes of trade.[34] The design was

22. Ibid, 77
23. Ibid, 81
24. Hadingham
25. Levathes, 82
26. Ibid
27. Ibid
28. George R Schwartz, "History of the Caravel" (MA thesis, Texas A&M, 2006; accessed 2 December 2007); available from http://nautarch.tamu.edu/shiplab/01George/caravela/htmls/Caravel%20History.htm
29. *Wikipedia*, 2007, "Caravel" Accessed 2 December 2007 Available from: http://en.wikipedia.org/wiki/Caravel
30. *Wikipedia*, 2007, "Carrack" Accessed 2 December 2007 Available from: http://en.wikipedia.org/wiki/Carrack
31. Fernand Braudel, *Civilization and Capitalism* [book online] (Los Angeles: University of California, 1992, accessed 2 December 2007); available from http://books.google.com/books?id=rPgVp3vMOjcC&pg=PA423&lpg=PA423&dq=carrack+displacement&source=web&ots=0MNwF2TVin&sig=KTIOJxUc6AIW9V-LiUHFvLIxvmoA
32. Wu
33. *Wikipedia*, 2007, "Carrack" Accessed 2 December 2007 Available from: http://en.wikipedia.org/wiki/Galleon
34. Ibid

purpose-built for war, with the notable exception of the Manila galleons.[35] These vessels were built out of oak (keel), pine (masts) and the hull and decks had various hardwoods.[36] The *Golden Hind,* Sir Francis Drake's vessel, was a galleon.

These primarily Venetian, Spanish and English-designed ocean-going vessels were ones that made a lasting of historical importance. But the overall designs of European ships were not limited to just these three nations' shipwrights: to ignore the Baltic powers, such as the Prussians, Swedes and Finns, would unjustly excommunicate the other major seafaring powers in the medieval era.

The cog, a flat-bottomed boat of Baltic origin, is believed to be a design dating as far back as 1299 CE.[37] The earliest examples were found upon the Rhine River[38], and spread throughout the region as the flat bottom allowed river travel, while the presence of the mainsail from 1100 CE onward[39] allowed it to catch the winds on the open ocean with some reliability. The later designs in the 14th and 15th centuries added forecastle-like platforms to the ships,[40] and at both the bow and stern but without the notable size of the carrack's forecastle or the galleon's sterncastle. The improved superstructure emplacements afforded protection for the sailors, but never truly caught on as the preferred design as the flat bottom prevented the cog from deep-ocean travelling, in the same way that smaller Chinese junks were flat bottomed and thus enable to undertake the heavier seas despite having a highly mobile spindle for the mast to rotate on.

A development of the cog design, the holk, was a purely-Baltic improvement on the cog appearing at about 1400 CE in significant numbers.[41] The multiple sail arrangement, which at about the same time the Chinese had managed to significantly advance to the 7 masts of the *Bao Chuan*, consisted of only 2 square sails, later modified by the 16th century with a third triangular sail[42] in the Venetian[43] or English style. Thus, even the harsh lessons of the Baltic and North Sea did not impart enough experience to European designers to build vessels on par with the Chinese ships, except in the plethora of sail types for particular purposes. The comparisons that can be drawn between the European designs and the Chinese naval ventures leans in favor of the Chinese in terms of technical mastery, economies of scale, armament relative to the threats, and overall size of the vessels. The Chinese had made a unique sail arrangement to partly mimic the lateen sail while using ship-rigged sails; the European designs either had to go with a mix of sails or only lateen to sail with, with the disadvantage of not being able to make full use of the prevailing winds while leveraging it against the maneuverability they would have against the wind. The Chinese had a notably larger displacement, meaning that their ships were carrying more than the European vessels at the time and afterwards, per ship type. But this has to be balanced by the knowledge that the Europeans continued to build vessels after their initial exploration and trade routes were formed; the Chinese lost out on this due to their political hostility to oceanic ventures and the distaste by Confucian officials' of a eunuch. The Chinese vessels outgunned their immediate contemporaries, but because of the loss of the fleet after Zheng He's death, this fact may well be irrelevant, as the various European ships would be armed as well as, if not better than, the Chinese within a century of the Treasure Fleet's dismantling.

The technical feats of off-center mast emplacement, watertight multiple bulkheads, the first use of a compass, and a reinforced hull with internal bulwarks displayed Ming naval engineering at its finest. Their vessels outsized and carried vastly more cargo tonnage than the largest of their European contemporaries. And yet, tragically, this would be the high-water mark for the Chinese in naval affairs for centuries. Only in the late 20th and early 21st centuries has China begun to grasp the technological strength it once had and stretch itself beyond its shallow rivers and coastal waters to the great blue beyond.

35. Ibid
36. Ibid
37. Jerry Litwin, "Shipbuilding Techniques from the Medieval Age Onwards" Accessed 13 December 2007, page 151. Available from http://www.cmm.pl/1stCHFpdf/pdf_articles/6.1_Litwin.pdf
38. Litwin, 150
39. Ibid, 149
40. Ibid, 151
41. Ibid, 151
42. Ibid, 151
43. Ibid, 152

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